

STUDIES ON THE DEVELOPMENT OF THE LABIAL TEETH ROW STRUCTURE IN *RANA CURTIPES* JERDON TADPOLES¹

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(With one plate)

Key words: *Rana curtipes*, development, metamorphosis, labial teeth, tadpoles

The development of the labial teeth row structure of anuran tadpoles of the temperate regions has been studied. However, similar studies on tropical species are scant. The present study is an attempt to describe the ontogeny of the labial teeth row structure of *Rana curtipes*, an endemic species of the Western Ghats of India. *R. curtipes* tadpole has the highest reported number of labial teeth rows, with marginal teeth, among tropical frogs.

INTRODUCTION

The teeth of frogs function primarily to grasp prey, or to position it for swallowing. Their distribution is known to be variable even among closely related groups (Altig 1970). The oral armature of the larvae differs from that of the adults, as they differ in feeding habits.

The ontogeny of the labial teeth row structure of anuran tadpoles inhabiting temperate regions has been studied by several workers (Taylor 1942, Zweifel 1964, Altig 1970, Lee 1976, Webb and Korky 1977, Hero 1990 and Davies 1992). However, our knowledge of the Indian amphibians is scant. Rao (1914), Lobo (1961), Chari (1962), Daniel (1975), Inger *et al.* (1984) and Sekar (1990a) have given brief notes on the mouth parts of Indian amphibians. Agarwal and Niazi (1980), and Dutta and Mohanty-Hejmadi (1983) have reported the ontogeny of the teeth row structure in *Rana tigerina* (now *Hoplobatrachus tigerinus*). The present paper describes changes in the teeth row structure of *Rana curtipes* tadpoles during metamorphosis.

MATERIAL AND METHODS

Fertilized eggs collected from natural habitat

¹Accepted July, 1999

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were used for the study. Freshly collected eggs were divided into groups of 50 and transferred to a large aquarium (maintained at a photoperiod of 12L:12D at 29 ± 2 °C) containing fresh pond water. After hatching, the tadpoles were divided into groups of 10 to avoid overcrowding, and reared in an aquarium of the same size (Group A). Water was changed every second day, and the tadpoles were fed *ad libitum* with boiled spinach. The developing eggs and embryos were observed under binocular microscope to note morphological changes at one hour intervals. Embryos and larvae were staged according to Gosner (1960) system for *Rana pipiens*. Tadpoles of earlier stages were preserved in 5% and later in 10% formaldehyde. Morphological features of the oral armature were studied, and the teeth row formula was determined as per Altig (1970) modified by Webb and Korky (1977), to introduce the "marginal teeth". Tadpole stages from feeding stage onwards were collected from a natural habitat near Thekkady (76° 50 'E, 9° 45 'N), Kerala (Group B). Twenty to thirty tadpoles were examined at each developmental stage.

RESULTS

The number of teeth rows changed with growth. The tadpoles collected from swift waters (stream) had more teeth rows than those reared in the aquarium. A list of teeth row formulae of tadpoles reared in the aquarium at 29 ± 2 °C, and those collected from a stream, have been presented in Tables 1 and 2.

TABLE I
LABIAL TEETH ROW FORMULA OF RANA CURTIPES
TADPOLES

Stages	Group A Reared in aquarium		Group B Collected from natural habitat (stream)
	Formula	Percent	Formula
External gill stage	Without teeth	—	Not collected
One external gill covered stage	1/0/2(1)	53	Not collected
	1/0/3(1)	47	
Operculum complete stage	1/0/2(1)	20	Not collected
	2(2)/0/2(1)	53	
	2(2)/0/3(1)	27	
Feeding stage	3(3)/0/3(1)	59	3(3)/0/3(1)
	3(3)/0/4(1)	41	3(3)/0/4(1)
Prelimb stage	4(3-4)/0/4(1)	20	4(3-4)/0/4(1)
	5(3-5)/0/4(1)	46	5(3-5)/0/4(1)
	5(3-5)/0/5(1)	26	5(3-5)/1/5(1)
	5(3-5)/0/6(1)	8	6(3-6)/1/6(1)
Limb bud stage	5(3-5)/1/5(1)	14	6(3-6)/1/6(1)
	6(3-6)/0/6(1)	30	7(3-7)/2/6(1)
	6(3-6)/1/6(1)	36	8(3-8)/3/7(1)
	7(3-7)/1/6(1)	20	8(3-8)/4/8(1)
Foot paddle stage			9(3-9)/4/7(1)
			9(3-9)/4/8(1)
	7(3-7)/2/6(1)	27	8(3-8)/3/7(1)
	7(3-7)/2/7(1)	34	8(3-8)/4/8(1)
	8(3-8)/3/6(1)	39	9(3-9)/5/7(1)
Foot stage			9(3-9)/5/8(1)
			10(3-10)/5/8(1)
	7(3-7)/2/7(1)	22	8(3-8)/2/8(1)
	8(3-8)/0/7(1)	56	9(3-9)/2/7(1)
	8(3-8)/2/6(1)	22	9(3-9)/3/8(1)
Well developed hindlimb stage			9(3-9)/4/8(1)
			10(3-10)/3/8(1)
	7(2-7)/0/7(1)	36	8(3-8)/0/7(1)
	8(3-8)/0/6(1)	31	9(2-9)/0/8(1)
One forelimb stage			9(3-9)/0/8(1)
			10(2-10)/1/8(1)
			10(3-10)/1/8(1)
Both limb and tail stage	7(1-7)/0/4(1)	61	9(3-9)/0/6(1)
	8(2-8)/0/6(1)	39	8(2-8)/0/7(1)
Froglet stage			7(1-7)/0/6(1)
			5(1-5)/0/3(1-3)
			4(1-4)/0/2(1-2)
			3(1-3)/0/3(1-3)
	5(1-5)/0/3(1-3)	8	5(1-5)/0/3(1-3)
	4(1-4)/0/3(1-3)	32	4(1-4)/0/2(1-2)
	4(1-4)/0/2(1-2)	33	3(1-3)/0/3(1-3)
	3(1-3)/0/2(1-2)	27	
	Without labial teeth		Without labial teeth

Hatching and external gill stage: The stomodaeum, at the antero-ventral region, was a deep oval pit at the time of hatching. At the external gill stage, it consisted of a pair of oval, black, non-serrated beaks without labial teeth and papillae. However, small indistinct ridges could be seen on the lateral and ventral margins, foreshadowing the labial teeth and papillae.

One external gill covered stage: Tadpoles reached one gill covered stage with widened mouth, and a single row of papillae on the sides of the upper and lower jaws. The edges of the lower jaw had a single row of papillae, the anterior edge of the upper jaw lacked papillae. The beaks became weakly serrated. At this stage, 53% of the tadpoles reared in the aquarium at $29 \pm 2^\circ\text{C}$, had a teeth row formula of 1/0/2(1) and 47% had 1/0/3(1); with a combined formula of 1/0/2-3(1) (Table 2). There was only one uninterrupted row in the upper jaw. The number varied from 2 to 3 in the lower jaw, the first being interrupted by a medial gap. Marginal teeth were absent.

Operculum complete stage: At this stage, 20% of the tadpoles examined had 1/0/2(1) (Table 1), 53% had 2(2)/0/2(1), and 27% had 2(2)/0/3(1) formulae. The first row in the upper, and the second and third in the lower jaw, when present, were uninterrupted. However, the first row in the lower, and the second in the upper jaw, were centrally broken. In the majority of tadpoles, teeth in the two jaws were weakly developed. The combined teeth row formula was 1-2(2)/0/2-3(1).

Feeding stage: A single row of labial papillae appeared around the lateral and posterior margin of the antero-ventral mouth. The second continuous row of teeth in the upper jaw appeared for the first time. The third and fourth rows of ventral jaw were poorly developed; marginal teeth were not present at this stage. The teeth row formula varied from 3(3)/0/3(1) to 3(3)/0/4(1), in two groups of tadpoles, and thus the combined formula 3(3)/0/3-4(1) was the same for both groups.

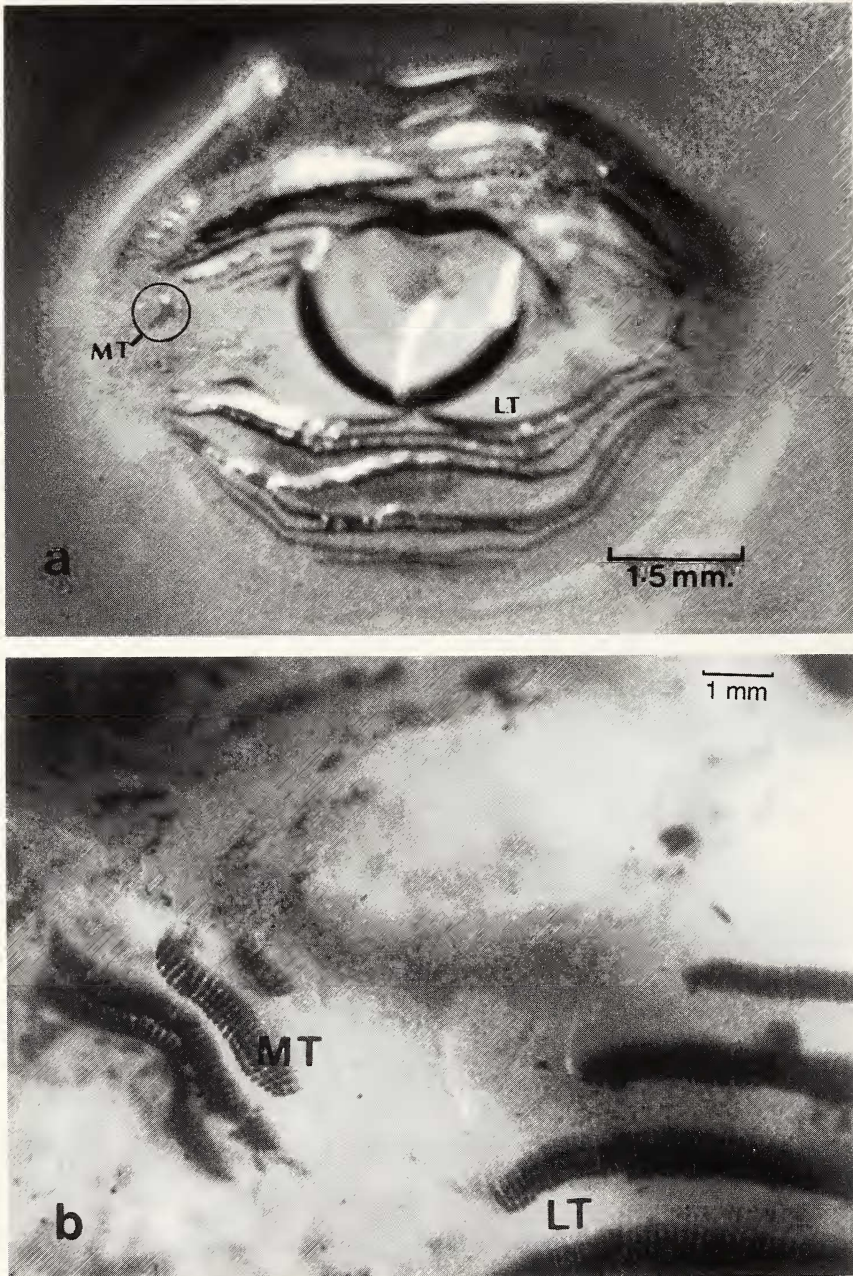


Fig. 1: a. Mouth parts of a tadpole of *Rana curtipes* at foot paddle stage (stage 34).

b. Marginal teeth of a tadpole of *R. curtipes* at foot paddle stage (stage 34).

LT - labial teeth, MT - marginal teeth.

TABLE 2
COMBINED LABIAL TEETH ROW FORMULA OF RANA CURTIPES TADPOLES

Stages	Group A Reared in aquarium	Group B Collected from natural habitat (stream)	General combined formula
External gill stage	Without teeth	Not collected	Nil
One external gill covered stage	1/0/2-3(1)	Not collected	1/0/2-3(1)
Operculum complete stage	1-2(2)/0/2-3(1)	Not collected	1-2(2)/0/2-3(1)
Feeding stage	3(3)/0/3-4(1)	3(3)/0/3-4(1)	3(3)/0/3-4(1)
Prelimb stage	4-5(3-5)/0/4-6(1)	4-6(3-6)/0-1/4-6(1)	4-6(3-6)/0-1/4-6(1)
Limb bud stage	5-7(3-7)/0-1/5-6(1)	6-9(3-9)/1-4/6-8(1)	5-9(3-9)/0-4/5-8(1)
Foot paddle stage	7-8(3-8)/2-3/6-7(1)	8-10(3-10)/3-5/7-8(1)	7-10(3-10)/2-5/6-8(1)
Foot stage	7-8(3-8)/0-2/6-7(1)	8-10(3-10)/2-4/7-8(1)	7-10(3-10)/0-4/6-8(1)
Well developed hindlimb stage	7-8(2-8)/0/6-7(1)	8-10(2-10)/0-1/7-8(1)	7-10(2-10)/0-1/6-8(1)
One forelimb stage	7-8(1-8)/0/4-6(1)	7-9(1-9)/0/6-7(1)	7-9(1-9)/0/4-7(1)
Both limb and tail stage	3-5(1-5)/0/2-3(1-3)	3-5(1-5)/0/2-3(1-3)	3-5(1-5)/0/2-3(1-3)
Froglet stage	Nil	Nil	Nil

Prelimb stage: The teeth row formulae of the tadpoles reared at 29 ± 2 °C were 20% 4(3-4)/0/4(1), 46% 5(3-5)/0/4(1), 26% 5(3-5)/0/5(1) and 8% 5(3-5)/0/6(1). The last row of the lower jaw in 70% of the tadpoles was poorly developed. The combined formula 4-5(3-5)/0/4-6(1) indicated that, of 4 to 5 rows in the upper jaw, the first two rows were uninterrupted, marginal teeth were absent and in the lower jaw the teeth rows varied from 4 to 6, with the first row uninterrupted. Two rows of submarginal papillae could be seen on the sides of the upper and lower jaws.

The combined teeth row formula, 4-5(3-5)/0/4-6(1), of tadpoles reared in the lab indicates the presence of a maximum of five rows in the upper jaw and six rows in the lower jaw. The combined teeth row formula of tadpoles collected from the stream was 4-6(3-6)/0-1/4-6(1). One row of marginal teeth was observed for the first time in 40% of the tadpoles.

Limb bud stage: In this stage of development, Group A had 14% 5(3-5)/1/5(1), 30% 6(3-6)/0/6(1), 36% 6(3-6)/1/6(1) and 20%

7(3-7)/1/6(1) labial teeth row formulae. Group B tadpoles varied widely in the number of teeth rows at this stage (Table 1). One row of marginal teeth appeared for the first time in tadpoles reared in the aquarium. Another characteristic was the development of two to three rows of sub-marginal papillae on the sides of both jaws. The lower and upper beaks were strong, serrated and keratinized. As in some of the previous stages, the last row of labial teeth in the lower jaw was poorly developed, or incomplete. The combined teeth row formula was 5-7(3-7)/0-1/5-6(1) in Group A and 6-9(3-9)/1-4/6-8(1) in Group B.

Foot paddle stage: The combined teeth row formulae of Group A [7-8(3-8)/2-3/6-7(1)] and Group B [8-10(3-10)/3-5/7-8(1)] indicated that maximum upper labial, lower labial and marginal teeth appeared for the first time in this stage. Maximum upper labial teeth rows in Group A were 8 and in Group B 10. Similarly, the maximum marginal teeth rows observed in Group A were 3. In Group B, the minimum and maximum marginal teeth rows were 3 and 5 respectively (Plate 1). All the rows of teeth in

the upper and the lower jaws were well developed.

Foot stage: In Group A tadpoles, 22% had 7(3-7)/2/7(1), 56% had 8(3-8)/0/7(1) and the remaining 22% had 8(3-8)/2/6(1) formulae. Thus, 78% of tadpoles of Group A at this stage had 8 rows in the upper jaw. Another feature at this stage was the reduction in marginal teeth. 56% in Group A had completely lost their marginal teeth. Likewise, in Group B, the majority had less than 4 rows of marginal teeth.

A comparison between foot paddle and foot stages indicates that while there was an increase in the percentage of labial teeth row number in foot stage, a decrease in marginal teeth row number also occurred in both groups of tadpoles at the foot stage.

Well developed hindlimb stage: All the tadpoles of Group A and a number of tadpoles in Group B had lost their marginal teeth. Second labial teeth row became broken in 69% of tadpoles. Thus, reduction or shedding of labial teeth had started at this stage. None of the tadpoles had the full complement of teeth at this stage.

One forelimb stage: Teeth row formula varied from 7(1-7)/0/4(1) to 8(2-8)/0/6(1) in Group A tadpoles. The combined formula of Group B was 7-9(1-9)/0/6-7(1). In the majority of tadpoles, both upper and lower jaw had intermittently broken labial teeth rows. The shedding of labial teeth had already started prior to this stage. The rows of sub-marginal papillae were absorbed, and limited to the corners of the mouth. The number of papillae decreased in the lower jaw. The horny beaks, both upper and lower, became thick, colourless or white, except at the edges where they were black at this stage.

Both limb and tail stage: In both groups of tadpoles, the combined teeth row formula was the same, 3-5(1-5)/0/2-3(1-3). All the rows in the upper and lower jaws were interrupted with lost teeth, and limited to the corners of the mouth. The labial fringes, which were present on the

lateral sides of mouth in the previous stages, were absorbed and papillae were seen in small clusters at the corners of the mouth. The horny beaks disappeared. The mouth widened, and the corners reached the level of the posterior margin of the eyes.

DISCUSSION

The present study shows that there are variations in the development of labial teeth row structure in tropical anurans. The number of teeth rows changes with the stage of development, and for each stage there are individual variations. Table 1 indicates that labial teeth appear at the one external gill covered stage, and reach a full complement of rows at the foot paddle stage. Labial teeth rows maintain this full complement up to the well-developed hindlimb stage. Before the onset of metamorphosis, labial teeth begin to shed and disappear with the completion of metamorphosis. Dutta and Mohanty-Hejmadi (1983) reported a similar pattern in *Rana tigerina* (now *Hoplobatrachus tigerinus*). Further, the present study shows that the teeth rows in the upper jaw vary from 1 to 10. Similarly, the labial teeth rows in the lower jaw vary from 2 to 8. The combined teeth row formula for *Rana curtipes* according to Rao (1914) is 6-8(4-8)/6-8(1), and Sekar (1990b) is 7(3-7)/5-8(1) or 7(4-7)/5-8(1). The present observation agrees with the views of Rao (1914) and Sekar (1990b) in the maximum number of rows and nature of the first row in the lower jaw.

The present study established that *Rana curtipes* tadpoles have marginal teeth, which make their first appearance in the prelimb stage (Table 2), reach a maximum at the foot paddle stage, and begin to disappear at the foot stage. The number of marginal teeth varies from 0 to 5 in *Rana curtipes*. Similar findings have been reported in *R. pustulosa* (Taylor 1942), *R. tarahumarae* (Zweifel 1955) and *R. macroglossa* (Volpe and Harvey 1958). But none have reported

the presence of marginal teeth in a tropical anuran.

Some differences were also found in the number of teeth rows between aquarium reared tadpoles, and those collected from their natural stream habitat. The tadpoles developed in the aquarium differ significantly from those collected from streams in the number, pattern and percentage of occurrence of labial and marginal teeth rows. In *Rana curtipes*, 10 rows of labial teeth in the upper and 8 rows in lower jaw indicate that the species has the largest number of labial teeth rows among tropical frogs. Labial teeth row formulae reported by Inger *et al.* (1984) for *R. temporalis* [2(2)/0/2(1)], *R. beddomi* (now

Indirana beddomii) [4(4)/0/4(1-2)] and *R. keralensis* (now *Limnonectes keralensis*) [2(2)/0/3], by Chari (1962) for *R. malabarica* [1/0/2(1)] and by Sekar (1990b) for *Rhacophorus malabaricus* [6(3-6)/0/3(1)], were less than those of *Rana curtipes*. The maximum number reported for *R. tigerina* (now *Hoplobatrachus tigerinus*), by Dutta and Mohanty-Hejmadi (1983), was 5(2-5)/0/(1-3).

The above observations reveal that *Rana curtipes* has the largest number of labial teeth rows among tropical anurans and the number of teeth rows changes with the development of tadpoles.

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